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Effects of grazing intensity on bird assemblages and populations of Hungarian grasslands

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Abstract

Agricultural intensification is responsible for the dramatic decline of farmland bird populations in the European Union (EU). The joining of eight Central and Eastern European (CEE) countries to the EU will re-structure agriculture there. One of the main threats is the intensification of farmland management. Can agri-environmental programs balance the expected decline in bird assemblages of the CEE countries if farming will be intensified? We studied this question by comparing bird assemblages of 42 extensively and intensively grazed paired fields in three regions of Hungary (alkali steppes and meadows in Central Hungary and alkali steppes in Eastern Hungary). Bird assemblages varied significantly across regions and grazing intensity. Intensively grazed sites showed a higher species number and diversity, but lower densities than the extensive sites. This is probably the consequence of higher landscape diversity of intensive sites, which included farm buildings, shelters, wells and other structures. Several bird species, mainly with European conservation concern, showed contrasting responses to grazing intensity in the three regions, including key grassland species (black-tailed godwit *Limosa limosa*, redshank *Tringa totanus*, skylark *Alauda arvensis* and corn bunting *Emberiza calandra*). Therefore, threat and sensitivity to grassland characteristics are correlating. Although many of the declining species of Western Europe are still abundant in Hungarian grasslands, our results project the threat of the expected intensification. This study showed that it is not possible to provide a general grassland management scheme that will favour all bird species in all regions of Hungary. In the process of integrating to the EU and re-structuring agriculture, the establishment of scientifically sound schemes is urgent.

Keywords: Farming; Agriculture; Agri-environmental scheme; Pannon biogeographic region; Skylark; Corn bunting; Redshank; Yellow wagtail

1. Introduction

There is overwhelming evidence that farmland species diversity is declining if management intensity is increasing (e.g. Duelli et al., 1999; Wilson et al., 1999; Stoate et al., 2001; Robinson and Sutherland,

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2002; Darkoh, 2003; Primdahl et al., 2003). This was found for mammals (Lundstrom-Gillieron and Schlaepfer, 2003; Pena et al., 2003), butterflies (Maes and Van Dyck, 2001), carabids (Kromp, 1999; Wilson et al., 1999; Benton et al., 2002), plants (Andreasen et al., 1996; Wilson et al., 1999; Zechmeister et al., 2003) and for birds both in Europe (Petersen and Jacobsen, 1997; Siriwardena et al., 1998; Schifferli et al., 1999; Donald et al., 2001; Hole et al., 2002) and in North America (Giuliano and Daves, 2002; Murphy, 2003). The decline is expected to continue (Tilman et al., 2001).

One of the responses of policy makers to the declining farmland biodiversity was the introduction of the agri-environmental schemes (AESs). In these schemes farmers are paid for nature friendly management, e.g. for organic farming, maintaining extensive systems, or for habitat management (Ovenden et al., 1998; Donald et al., 2002). Roughly 20% of the EU's farmland is managed according to some form of such schemes, costing billions of euros (Kleijn et al., 2001). However, the efficiency and benefits of schemes are rarely monitored. In their review, Kleijn and Sutherland (2003) searched for evaluations of agri-environmental schemes in 26 countries in Europe, but found such studies in six countries only. Furthermore, the design of most evaluation studies was inadequate for a reliable assessment of the effectiveness of the AESs. The few results published in international journals show contrasting effects. Several studies did not find any effects of the schemes on diversity. For example, there was no significant relationship between plant species richness and the amount of subsidies invested in Austrian meadows (Zechmeister et al., 2003). Kleijn et al. (2001) found that management agreements were not effective in protecting the species richness in Dutch agricultural landscapes. In contrast, the scheme aiming to promote the cirl bunting (*Emberiza cirlus*) in the UK proved to be successful, the number of breeding pairs increased by 83% between 1992 and 1998 (Peach et al., 2001). The few other examples of successful AESs suggest that these were closely supervised (Kleijn and Sutherland, 2003).

Eight Central and Eastern European Countries (CEE countries) have just joined the EU. However, this may cause threats to their natural values, especially on agricultural lands. In the EU the market regulations and support diminish national and regional differences (Jongman, 2002). When the CEE countries join the EU the Common Agricultural Policy (CAP) is introduced. This will seriously affect the agriculture-related economy (e.g. Kavcic et al., 2003). Hertel et al. (1997) showed that such an economic integration will result in substantial increases of both crop and livestock production. In addition, the CAP will extend the homogenisation process of agricultural landscapes to CEE countries and is thereby likely to adversely affect the local farmland bird populations (Donald et al., 2002).

Currently, many of the bird species declining in Western Europe are still abundant in CEE countries. For example, the skylark (*Alauda arvensis*), tree sparrow (*Passer montanus*), red-backed shrike (*Lanius collurio*), stonechat (*Saxicola torquata*), yellowhammer (*Emberiza citrinella*) and corn bunting (*Emberiza calandra*) are among the 25 most frequent breeding species in Hungary (Szép and Nagy, 2002). These species suffered a dramatic population decline in Western Europe in the last decades (Siriwardena et al., 1998; Schifferli et al., 1999; Teunissen and Hagemeijer, 1999; Donald et al., 2001).

Agricultural land covers two-thirds of Hungary's surface. This is the highest value among the CEE countries, and third highest considering all European countries (Donald et al., 2002). Therefore, the conservation of the relatively high diversity of Hungarian agricultural landscapes is the key to maintain the unique biota of the Pannon biogeographic region, which covers Hungary and areas from neighbouring countries.

The Pannon biogeographic region is unique largely because of its steppic grassland habitats (Varga, 1995, 1997; Fekete et al., 2002; Molnár and Borhidi, 2003). Grasslands covered almost one-third of Hungary in the 19th century, but currently make up only 10% of the country's area. Over centuries, traditional grazing and grassland management resulted in high diversity of habitats (Kelemen, 1997). This so-called ''puszta'' consists of dry short steppes, wet meadows, alkali marshes, trees and small forest patches, and small farms. The importance of grasslands is appreciated, and one of the four programmes of the Hungarian agri-environmental programme is the grassland management programme (Ángyán et al., 1999).

AESs are recently being introduced into CEE countries with the aim to conserve biodiversity (Roudna and Dotlacil, 2002). Can we expect major effects? The Hungarian Agri-Environmental Programme (HAEP) (Ángyán et al., 1999) was initiated in 2002, therefore, it is not yet possible to test long-term effects. However, for many years the management of protected grasslands has been similar to the one specified in the grassland management programme of the HAEP. Therefore, comparing biodiversity on these protected grasslands with intensively grazed grasslands can predict the effects of AESs. Considering the uncertainty of success of AESs in Europe (Kleijn and Sutherland, 2003), it is urgent to start research in Hungary and other CEE countries on the relationship of management intensity and biological diversity. Without well-established research results and a sound scientific background, there is a high risk to waste the limited financial resources on ineffective schemes (Kleijn and Sutherland, 2003). With this study we try to fill this gap for the lowland grasslands of the Pannon biogeographic region, and provide research results to assess the effects of introducing CAP into Hungary. Our aims are: (1) to test the influence of grazing intensity on grassland bird communities of the Hungarian Great Plain; (2) to provide guidelines for the proper introduction of the AES in Hungary, and other CEE countries.

2. Materials and methods

2.1. Study areas

Forty-two census sites were selected in three distinct biogeographic regions in the Great Plain in Hungary (Fig. 1). The three regions differ in their vegetation and landscape structure. Two are located between the Danube and the Tisza Rivers. The first ‘‘Alkali region’’ is situated in the former flood area of the Danube River, which is flat and characterised by large landscape units, and simple landscape structure. As a consequence of river and water regulations, the process of salinisation accelerated, resulting in secondary Pannonic alkali steppe vegetation on solonchak–solonetz soils. The flora consists of common grass species like the false sheep's fescue (*Festuca pseudovina*) and bermudagrass (*Cynodon dactylon*), and salt resistant species like the sea wormwood (*Artemisia santonicum*), sea lavender (*Limonium gmellini*), chamomile (*Matricaria chamomilla*) and the *Podospermum canum*.

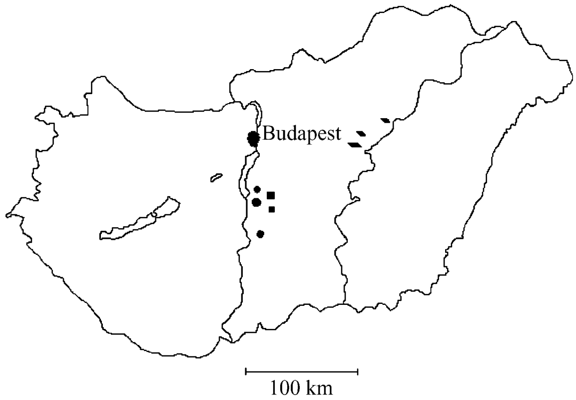

Fig. 1. The location of study sites in Hungary. The circles indicate the research areas in the Kiskunság Alkali region, the squares indicate the research areas in the Kiskunság Meadow region, and the rhombuses indicate the research areas in the Heves region. All areas had seven pairs of extensively–intensively grazed field. Kiskunság Alkali areas from the North to South: Apaj (one pair), Bösztörpuszta (four pairs) and Kelemenszék (two pairs); Kiskunság Meadow areas: Kunpeszér (four pairs) and Kunadacs (three pairs); Heves areas: Poroszló (two pairs), Tarnaszentmiklós (two pairs) and Pély (three pairs).

The ‘‘Meadow region’’ is located in the northern part of the Danube-Tisza interfluve. Distinctive features are the transient geographical position between a sand dune and the Alkali regions, and the varying geomorphological structure. This resulted in a complex and diverse landscape. The main characteristic of this site is the patchy habitat structure, a mosaic of swamp meadows, calcareous purple moorgrass meadows, salt steppes and Pannonic sand steppe grasslands, with scattered small forests. Dominant plant species are the false sheep's fescue (*F. pseudovina*) and bermudagrass (*C. dactylon*), while characteristic species are the purple moorgrass (*Molinia caerulea*), tufted hairgrass (*Deschampsia caespitosa*), cinquefoil species (*Potentilla anserina*, *P. reptens*, *P. neglecta*) and 28 orchid species.

The ‘‘Heves region’’ is situated near the River Tisza, 100 km to the East of the former two regions. It consists of a mosaic-complex of dry and wet alkali grasslands and marshes on solonetz soil. Dominant plant species are the false sheep's fescue (*F.

pseudovina), quackgrass (*Elymus repens*) and *Scorzonera cana*. Characteristic species are the sea plantain (*Plantago maritima*), the sea wormwood (*A. santonicum*), the whitetop (*Cardaria draba*) and yarrow (*Achillea*) species.

2.2. Sampling design

We selected field pairs with high and low grazing pressure in the vicinity of each other. Therefore, the systematic differences of fields within pairs can be attributed to the intensity of grazing, and other environmental factors may have little effect. Similar paired-field designs were already successfully used in other studies (e.g. Kleijn et al., 2001; Suominen et al., 2003). Each region had seven field pairs, consisting of an extensively and an intensively grazed site. For both types, the intensity of grazing was roughly constant over the last 5 years. The grazing regimes were typical to the puszta grasslands. The cattle density was about 0.5 cows per hectare on extensive, and >1 cow per hectare on intensive fields. None of the fields were fertilised. In eight pairs the intensive sites were selected in intensively grazed lands of private companies neighbouring protected areas. The extensive fields of these eight pairs were within the protected areas, where nature-friendly grazing practice is applied. No long-term extensive grazing sites are available outside protected areas. In 13 pairs, both the intensive and extensive sites were within the same pasture. Those parts of the pastures, where the cattle grazed intensively or spent more time were categorised as intensive. These were near the shelter or the watering wells. The extensive sites were selected in remote parts of the pastures, where the cattle grazed less frequently. This site selection approach was possible, because the size of the pastures was as large as 100 ha, sometimes over 1000 ha, and the number of cattle was 100–400. Therefore, the frequently grazed intensive and less frequently grazed extensive sites were clearly distinguishable.

2.3. Census methods and selection of species for the analysis

Each census site was 12.5 ha, usually in a square shape. The sites were visited four times in the breeding season (April and May) 2003. Censuses were carried out under good weather conditions (no wind and rain), from sunrise to 9–10 am. The extensive and intensive fields of each pair were censused in the same morning by the same observer. The order in which sites were sampled was changed in the consecutive censuses. The observer spent at least 30 min at a site, slowly walking a transect. In case of many birds, the census of a single site may have taken more than an hour. All bird observations, heard or seen, were recorded. Birds just flying through were excluded from the analysis.

We compiled three datasets from the observations. The first contained all bird species of the censuses, and was used for the calculation of standard assemblage features (e.g. diversity). The second dataset contained the abundant species only. A species was considered abundant, if the total number of individuals was greater than 5, and if it was recorded at least on three occasions (census or site). Then the largest number of observations from the four censuses was used. This dataset was included to the multivariate analyses in order to avoid problems of bias which can occur if there are too many rare species, i.e., too many zeros in the matrix (Cao et al., 2001). The third dataset was a grassland bird dataset, where grassland birds were considered to be those species breeding and foraging in grasslands in Hungary, and nesting on the ground.

2.4. Data analysis

First, the standard features of the assemblages were evaluated separately for the three regions and for the extensively and intensively grazed paired fields. The standard features included the number of species, number of observed individuals, and the Shannon–Wiener diversity measure.

General linear modelling (GLM) was then used to analyse the effect of grazing, region, and the interaction between grazing and region on the number of individuals. This analysis was limited to the species which occurred in all the six samples of the three regions and two grazing intensities. Post-hoc least significant difference (LSD) pairwise multiple comparison tests were used to determine significant differences between groups ($p < 0.05$). We applied discriminant analysis to investigate differences between bird assemblages of the paired extensive and intensive pastures. The direct variable selection method was applied in discriminant analysis, where variables are considered for inclusion in one block. The discriminant function is usually important, i.e., the analysis performed well, if the Eigen value exceeds 1. The larger the Eigen value, the more of the variance in the dependent variable is explained by the discriminant function. Wilks' lambda tests were used to assess the significance of the Eigen value. The homogeneity of variances was tested by the Levene's test in the GLM, and if necessary, the variables were log(10) transformed. These analyses are relatively robust even when there are modest violations of the assumptions (Lachenbruch, 1975). SPSS 10.0 was used for analyses (SPSS, 1999).

3. Results

We recorded 3548 bird observations, belonging to 67 species (Table 1). The number of species was higher in the intensively grazed pastures of all regions, but only in the Heves Region this difference was statistically significant (Fig. 2, Table 2). The total number of individuals was higher on the extensive pastures, but not significantly due to large variations. The Shannon–Wiener diversity index, which combines richness and abundance, showed higher values for intensive pastures (significant for two of the three regions). The Meadow region was the most diverse, but with the lowest number of observations. The

Table 1
Common and scientific names of bird species recorded in the study of Pannonian grasslands

Abundant species[a]	Important rare species	Other rare species—not relevant in grassland management
Bee-eater *Merops apiaster*	Common buzzard *Buteo buteo*	Avocet *Recurvirostra avosetta*
Black-tailed godwit *Limosa limosa*[b]	Crested lark *Galerida cristata*[b]	Blue tit *Parus caeruleus*
Corn bunting *Emberiza. calandra*[b]	Golden plover *Pluvialis apricaria*	Bluethroat *Luscinia svecica*
Curlew *Numenius arquata*[b]	Goldfinch *Carduelis carduelis*	Chaffinch *Fringilla coelebs*
Grasshopper warbler *Locustella naevia*[b]	Great bustard *Otis tarda*[b]	Common shelduck *Tadorna tadorna*
Kestrel *Falco tinnunculus*	Green sandpiper *Tringa ochropus*	Common whitethroat *Sylvia communis*
Lapwing *Vanellus vanellus*[b]	Greenfinch *Carduelis chloris*	Coot *Fulica atra*
Lesser grey shrike *Lanius minor*	Hooded crow *Corvus corone cornix*	Cuckoo *Cuculus canorus*
Magpie *Pica pica*	Hoopoe *Upupa epops*	Garganey *Anas querquedula*
Mallard *Anas plathyrhynchos*	Linnet *Carduelis cannabina*	Golden oriole *Oriolus oriolus*
Montagu's harrier *Circus pygargus*[b]	Red-footed falcon *Falco vespertinus*	Great reed warbler *Acrocephalus arundinaceus*
Partridge *Perdix perdix*[b]	Rook *Corvus frugilegus*	Great white egret *Egretta alba*
Pheasant *Phasianus colchicus*[b]	Snipe *Gallinago gallinago*[b]	Grey heron *Ardea cinerea*
Quail *Coturnix coturnix*[b]	Spotted redshank *Tringa erythropus*	House sparrow *Passer domesticus*
Red-backed shrike *Lanius collurio*	White stork *Ciconia ciconia*	Meadow pipit *Anthus pratensis*
Redshank *Tringa totanus*[b]		Nightingale *Luscinia megarhynchos*
Reed bunting *Emberiza schoeniclus*[b]		Reed warbler *Acrocephalus scirpaceus*
Roller *Coracias garrulus*		Robin *Erithacus rubecula*
Ruff *Philomachus pugnax*		Spotted flycatcher *Muscicapa striata*
Savi's warbler *Locustella luscinioides*		Wheatear *Oenanthe oenanthe*
Sedge warbler *Acrocephalus schoenobaenus*		White wagtail *Motacilla alba*
Skylark *Alauda arvensis*[b]		
Starling *Sturnus vulgaris*		
Stone curlew *Burhinus oedicnemus*[b]		
Stonechat *Saxicola torquata*[b]		
Tawny pipit *Anthus campestris*[b]		
Tree sparrow *Passer montanus*		
Whinchat *Saxicola rubetra*[b]		
Wood pigeon *Columba palumbus*		
Wood sandpiper *Tringa glareola*		
Yellow wagtail *Motacilla flava*[b]		

[a] Total number of individuals > 5, number of records > 2.

[b] Grassland species (breeding and foraging in grasslands in Hungary, and breeding on the ground).

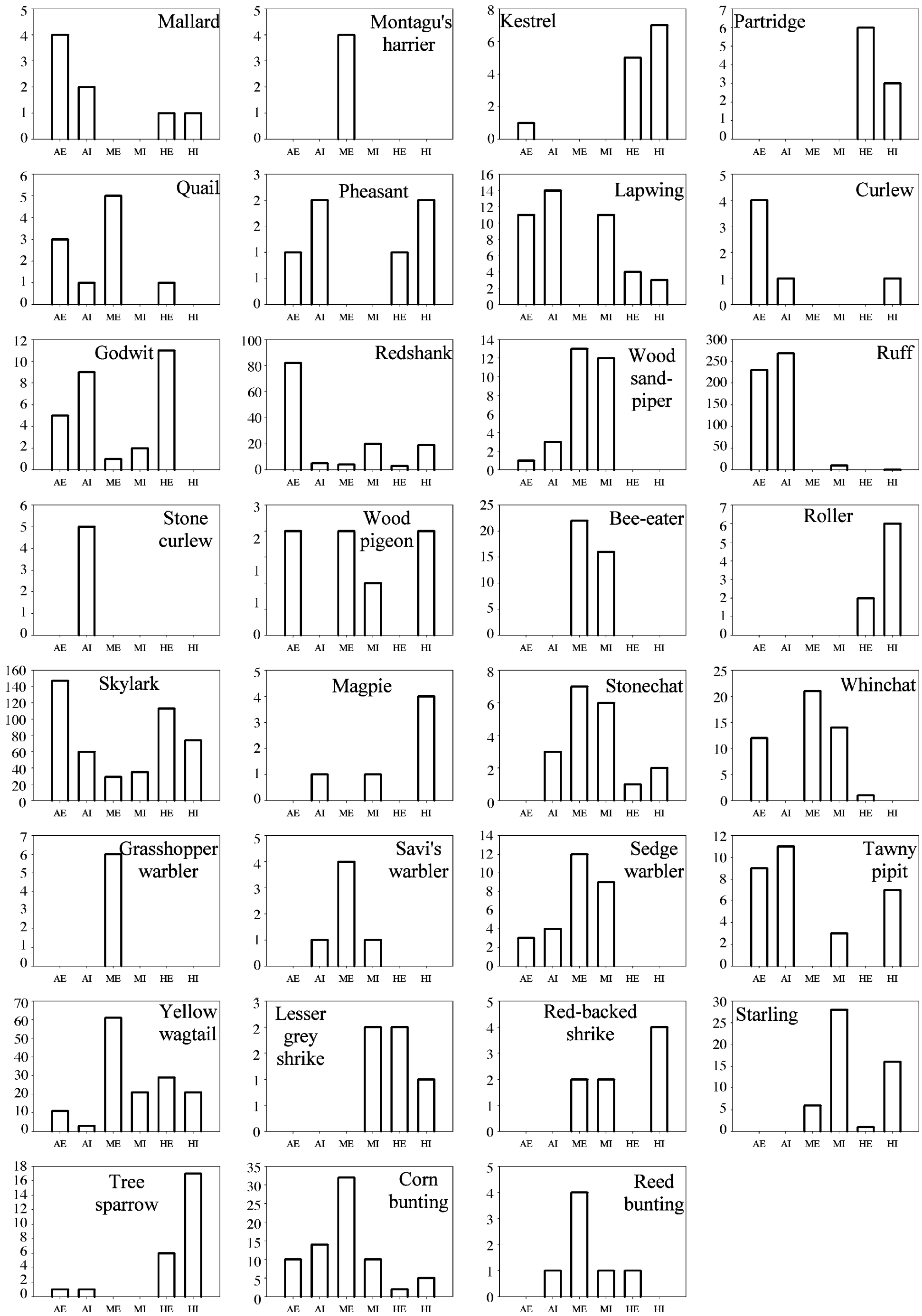

Fig. 2. Number of individuals on the 12.5 ha sample plots for the abundant species. All of the following categories had seven sample plots. AE: Alkali region, extensive sites; AI: Alkali region, intensive sites; ME: Meadow region, extensive sites; MI: Meadow region, intensive sites; HE: Heves region, extensive sites; HI: Heves region, intensive sites (note that the *y*-axis is scaled differently for each species).

Table 2
Comparison of assembly structure parameters of birds in extensively and intensively grazed paired pastures in Hungary (d.f. = 3)

	t	*p*[a]
Alkali region		
Species richness	−1.031	0.378
Abundance	1.264	0.295
Diversity	−1.354	0.269
Meadow region		
Species richness	−3	0.058
Abundance	3.013	0.057
Diversity	−4.689	**0.018**
Heves region		
Species richness	−5.196	**0.014**
Abundance	1.993	0.14
Diversity	−6.085	**0.009**

[a] Significant *p*-values of the *t*-tests are in bold.

highest variability was observed in the Alkali region.

The dataset of abundant species (see definition above), had 3247 observations of 31 species. The abundant bird species showed great, sometimes contrasting variations across locations and management regimes (Fig. 2). There were many species, where the presence was restricted to one (6 species) or two (11 species) regions. Kestrel, partridge, bee-eater and tree sparrow were among these (see Table 1 for scientific names of bird species). We evaluated whether the preference for extensive or intensive pastures was consistent across regions. The number of observations was used as a measure of preference and the species were grouped accordingly. Thirteen of the 31 abundant species (42%) showed mixed preference (Table 3). Species, which occurred in larger number in

Table 3
The preference of bird species for extensive vs. intensive grasslands in three regions of the Pannonian grasslands

Preference of extensive grassland[a]		Preference of intensive grassland[b]		Mixed preference[c]	
Abundant species[d]					
Mallard		Partridge	SPEC 3	Kestrel	SPEC 3
Montagu's harrier	SPEC 4	Pheasant		Curlew	
Quail	SPEC 3	Lapwing		Black-tailed godwit	SPEC 2
Bee-eater	SPEC 3	Wood sandpiper		Redshank	SPEC 2
Whinchat	SPEC 4	Ruff		Wood pigeon	SPEC 4
Grasshopper warbler	SPEC 4	Stone curlew	SPEC 3	Skylark	SPEC 3
Yellow wagtail		Roller	SPEC 2	Stonechat	SPEC 3
		Magpie		Savi's warbler	SPEC 4
		Red-backed shrike	SPEC 3	Sedge warbler	SPEC 4
		Starling		Tawny pipit	SPEC 3
		Tree sparrow		Lesser grey shrike	SPEC 2
				Corn bunting	SPEC 4
				Reed bunting	
Important rare species					
Great bustard	SPEC 1	White stork	SPEC 2	Snipe	
Golden plover		Common buzzard		Hooded crow	
Green sandpiper		Red-footed falcon	SPEC 3		
Hoopoe		Spotted redshank			
Rook		Crested lark	SPEC 3		
Linnet	SPEC 4	Greenfinch	SPEC 4		
		Goldfinch			

SPEC: SPecies of European Conservation concern. 1: Globally threatened species; 2: European species that have unfavourable conservation status; 3: global species that have unfavourable conservation status in Europe; 4: species with favourable conservation status in Europe, but whose populations are mainly in Europe. Species without SPEC category have favourable conservation status in Europe and may also have the majority of their population outside Europe (Tucker and Heath, 1994).

[a] Higher abundance on extensive sites in all three regions.

[b] Higher abundance on intensive sites in all three regions.

[c] Contrasting trends in abundance between the regions.

[d] See Table 1.

either the extensive, or the intensive fields had very similar total SPEC status (SPEC: SPecies of European Conservation concern; see the legend of Table 3 for explanation; Tucker and Heath, 1994). Five versus four species preferred extensive versus intensive grasslands, but the fewer species of the intensive fields yield slightly higher SPEC values. However, species with mixed preference, i.e., with larger number of individuals in extensive fields in one region, but in intensive at other region, were almost exclusively SPEC species, three of them have even unfavourable conservation status (SPEC 2).

Similarly, there was no overall preference for either of the pasture types in the rare species, although here the number of observation was low (Table 3). The globally threatened (SPEC 1) great bustard preferred the extensive pastures, while the white stork (SPEC 2), the red-footed falcon (SPEC 3) and the crested lark (SPEC 3) preferred the intensive pastures.

There were four species which occurred in all the three regions and two management categories. The effects of region, management and their interaction varied among the species (Table 4). Post-hoc comparisons of region preferences in the three species with significant region effects revealed that the number of corn bunting observations varied across the three regions, with significant differences between the Alkali–Meadow (LSD test, $p = 0.039$) and Heves–Meadow ($p = 0.000$) regions, and a slight difference between the Alkali and Heves areas ($p = 0.091$). The skylark abundance was different between the Alkali–Meadow and Heves–Meadow areas ($p = 0.000$, 0.001). The yellow wagtail numbers were different between Alkali and Meadow and between Alkali and Heves areas ($p = 0.000$, 0.002). Therefore, the corn bunting had different numbers in all areas, whereas the skylark and the yellow wagtail was present in similar high abundance in the two regions, and low abundance in the third (Meadow and Alkali, respectively).

Discriminant analysis was performed separately for bird assemblages of the three regions. There was a significant discrimination between bird assemblages of extensive and intensive pastures in the Alkali and Meadow regions; in the Heves region the difference was marginally significant (Table 5). The classification of cases was correct in 88% for the Alkali and the Meadow areas, and 84% for the Heves area.

Roughly half of the rare species (see definition above) were grassland species (Table 1). The dataset of grassland birds contained 2417 observations of 20 species. The results of the discriminant analyses, and the comparison of assemblage features between intensive and extensive pastures showed very similar

Table 4
The effects of region, grazing intensity (management) and their interaction on the abundance of four bird species of Hungarian grasslands

	Sum of square	d.f.	F	p[a]	Variance explained (%)
Corn bunting					
Region	1.06	2	7.53	**0.002**	30
Management	0.10	1	1.42	0.241	4
Interaction	0.37	2	2.61	0.087	13
Redshank					
Region	0.04	2	0.09	0.910	1
Management	0.09	1	0.44	0.511	1
Interaction	0.46	2	1.14	0.330	6
Skylark					
Region	856.62	2	11.21	**0.000**	38
Management	342.86	1	8.98	**0.005**	20
Interaction	309.00	2	4.04	**0.026**	18
Yellow wagtail					
Region	1.64	2	10.12	**0.000**	36
Management	0.87	1	10.73	**0.002**	23
Interaction	0.25	2	1.58	0.221	8

[a] Significant p-values are in bold.

Table 5
Results of the discriminant analysis of bird assemblages on extensive vs. intensive grasslands in three region in Hungary

	Alkali region	Meadow region	Heves region
Eigen value	1.689	1.826	1.232
Wilks' lambda	0.372	0.354	0.448
Chi square	42.036	44.153	33.712
d.f.	23	23	24
p	0.009	0.005	0.090
Classification (%)	88	88	84

patterns for the grassland bird species, and the other (all and abundant species) datasets. Therefore, these results are not presented separately.

4. Discussion

We recorded 67 bird species in Hungarian grasslands in this study, which is 18% of the total bird species richness of Hungary (Magyar et al., 1998). Lowland farmland in Europe provides the breeding or wintering habitat for nearly 120 SPEC species (Donald et al., 2002), of which 26 species (22%) were recorded during the four censuses on only 525 ha in this study. These comparisons indicate a rich farmland bird assemblage of the Pannonian grasslands, which highlights that farmland bird conservation must get priority during the enlargement of the EU (Donald et al., 2002).

Bird assemblages of the Pannonian grasslands were significantly affected by grazing intensity and location. Grazing possibly acts on the structure and composition of the vegetation and on the landscape structure. This is indicated by those species which showed preferences for different management regimes in different regions. For example the skylark preferred extensive pastures in the Alkali region, where the grass was higher (10–15 cm), than on the intensive pastures (5–10 cm). The Meadow region, however, had a different vegetation, with grass taller than 25 cm on the extensive and 5–10 cm on the intensive pastures. Therefore, the skylarks selected territories accordingly to their normal preferences: avoiding too short or too high swards. The effect of landscape structure is indicated by the increased bird species numbers on the intensive sites, which were usually near farm buildings, wells, or shelters, while extensive sites contained less structures and were more homogeneous.

The three regions had distinct bird assemblages. This has several reasons, including the differences in landscape complexity, soil type, water table and vegetation. This distinctness can only be preserved with the traditional management practices, which evolved according to the local possibilities. An EU level common agricultural system, like the CAP, may change management into the same practice in all regions. This may diminish the regional effect, resulting in homogeneous, and regionally poor assemblages (Jongman, 2002).

What changes are expected in the grassland bird communities following the EU enlargement? Three important points will be addressed here. Firstly, the grasslands still are relatively large in Hungary, 45% of the fields are larger than 50 ha, and only 20% are smaller than 5 ha (Kelemen, 1997). There is, however, a continuous decline in area inducing the fragmentation of grasslands (Kelemen, 1997; Molnár and Vajda, 2000). If the large Pannonian grasslands will be further fragmented, we may expect an increase of total species richness, and a decrease of grassland bird population sizes. The increase of species richness is expected, because fragmentation increases landscape heterogeneity due to new habitat edges, buildings, roads, etc. This heterogeneity is favoured by most taxa (Tscharntke et al., 2002; Benton et al., 2003; Duelli and Obrist, 2003). However, both Stoate et al. (2003) and we found that the abundance of grassland birds declined on the heterogeneous intensive areas.

Secondly, abandonment is an important issue in Hungary. After the collapse of communism and the change of economy, livestock decreased by >40% (Molnár and Vajda, 2000). Similar trends were observed in other CEE countries (Roudna and Dotlacil, 2002). The abandoned arable lands were infected by exotic weeds, like the common milkweed (*Asclepias syriaca*) (Csecserits and Rédei, 2001). On the abandoned pastures the grasslands are transforming to bushy areas then to forests during secondary succession (Hansson and Fogelfors, 2000; Kuiters and Slim, 2003). The appearance and increase of bush cover is modifying bird assemblages. Verhulst et al. (2004) found that on Hungarian grasslands not grazed for 15 years and scattered by bushes, the abundance of grassland birds declined. For example there were no waders in these abandoned grasslands, and the density of skylark was an order smaller than in the neighbouring extensively grazed grasslands. Of the grassland birds, only the corn bunting benefited from the growing of bushes (Verhulst et al., 2004). Therefore, abandonment seems to be harmful for farmland birds (MacDonald et al., 2000; Suárez-Seoane et al., 2002).

Thirdly, intensification may occur on sites with a high potential of production. An increase in the number of livestock may be beneficial for some bird species, e.g. for the stone curlew or the pratincole (*Glareola pratincola*) (Kelemen, 1997). However, intensification of grassland management may include the use of fertilisers and mowing besides grazing. Verhulst et al. (2004) showed that this resulted in the poorest bird assemblages in Hungary among three grazing regimes: extensive, intensive and intensive/fertilised grasslands. A similar trend was found by Vickery et al. (2001), who showed that the replacement of structurally diverse swards with fast growing, fertilised uniform swards might contribute to the decline of grassland bird communities in the UK.

The same agricultural policy across eco-regions cannot be assumed to bring uniform conservation benefits (Suárez-Seoane et al., 2002). We showed that no broad scale, general agri-environmental scheme can be applied for grasslands. Kleijn and Sutherland (2003) suggest that only those schemes are successful, and act for the benefit of wildlife, where the target is clearly defined in an operative way, and which are closely supervised by scientists. Based on the experience of our study we agree with this conclusion, because bird species showed rather complex, often contrasting responses to grazing intensity, which varied across locations. Further investigations are necessary to clarify the effects of confounding factors like landscape heterogeneity. The variability was most pronounced in the SPEC species. Therefore, we believe that no scheme will be successful in Hungary, if it is not clearly tailored for one, or a few species, in a given biogeographic region, and is not monitored and supervised effectively (Muller, 2002). However, any scheme that focuses on one or a few species will harm other taxa (e.g. Pärt and Söderström, 1999; Kruess and Tscharntke, 2002; Jeanneret et al., 2003), therefore the costs and benefits should be evaluated very carefully.

5. Conclusions and outlook

Based on our findings, we recommend to further evaluate the following options regarding the design of AESs in Hungary:

1. Decisions regarding target species, or species groups should be made at the national level, considering national priorities, international responsibilities (e.g. Birds and Habitats Directives of the European Union), available resources, etc.
2. The measures should be implemented by the national park directorates in Hungary. The administration of nature conservation in Hungary is subdivided into 10 such directorates, which probably can be more effective on shaping schemes to local conditions than a centralised body.
3. The monitoring and scientific supervision should be done at national, or at the Pannon biogeograhic region level.

From a practical point of view, the concentration on a few target species, which may indicate the naturalness of grasslands, would be useful. We can not recommend indicator species based on our study, but we can recommend candidate species, the indicator value of which should be investigated in detail. The skylark seems to be a candidate indicator taxa for the alkali grasslands between the Danube and Tisza Rivers, the yellow wagtail and the corn bunting for the meadows in the same area, and the tawny pipit and the red-backed shrike for the solonetz alkali grasslands in eastern Hungary.

The ongoing changes in the agricultural economy of CEE countries threaten the rich eastern European ecosystems. However, they also provide the great opportunity to direct changes for the benefit of wildlife (e.g. Pywell et al., 2002; Sutherland, 2002; Marggraf, 2003). It is partly the responsibility of the researchers' community to provide scientifically sound research background for the stakeholders during transitions. It is inevitable to increase the number and scope of such studies in CEE countries. Regarding this study, at least two further investigations are needed: one should be a quantitative analysis of the effects of landscape heterogeneity on bird assemblages. The other should focus on the effect of food resources on reproduction in extensive and intensive grasslands, because these were found to be the key factors of the decline in Western European farmland bird populations (Vickery et al., 2001; Benton et al., 2002).

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References

Andreasen, C., Stryhn, H., Streibig, J.C., 1996. Decline of the flora in Danish arable fields. J. Appl. Ecol. 33, 619–626.

Ángyán, J., Fésűs, I., Podmaniczky, L., Tar, F., Madarassy, A., 1999. Nemzeti Agrár-környezetvédelmi Program. Ministry of Agriculture and Rural Development, Budapest, Hungary.

Benton, T.G., Bryant, D.M., Cole, L., Crick, H.Q.P., 2002. Linking agricultural practice to insect and bird populations: a historical study over three decades. J. Appl. Ecol. 39, 673–687.

Benton, T.G., Vickery, J.A., Wilson, J.D., 2003. Farmland biodiversity: is habitat heterogeneity the key? Trends Ecol. Evol. 18, 182–188.

Cao, Y., Larsen, D.P., Thorne, R.St.-J., 2001. Rare species in multivariate analysis for bioassessment: some considerations. J. N. Am. Benthol. Soc. 20, 144–153.

Csecserits, A., Rédei, T., 2001. Secondary succession on sandy old-fields in Hungary. Appl. Veg. Sci. 4, 63–74.

Darkoh, M.B.K., 2003. Regional perspectives on agriculture and biodiversity in the drylands of Africa. J. Arid Environ. 54, 261–279.

Donald, P.F., Green, R.E., Heath, M.F., 2001. Agricultural intensification and the collapse of Europe's farmland bird populations. Proc. Roy. Soc. London B 268, 25–29.

Donald, P.F., Pisano, G., Rayment, M.D., Pain, D.J., 2002. The common agricultural policy, EU enlargements and the conservation of Europe's farmland birds. Agric. Ecosyst. Environ. 89, 167–182.

Duelli, P., Obrist, M.K., 2003. Regional biodiversity in an agricultural landscape: the contribution of seminatural habitat islands. Basic Appl. Ecol. 4, 129–138.

Duelli, P., Obrist, M.K., Schmatz, D.R., 1999. Biodiversity evaluation in agricultural landscapes: above-ground insects. Agric. Ecosyst. Environ. 74, 33–64.

Fekete, G., Molnár, Z., Kun, A., Botta-Dukát, Z., 2002. On the structure of the Pannonian forest steppe: grasslands on sand. Acta Zool. Hung. 48 (Suppl. 1), 137–150.

Giuliano, W.M., Daves, S.E., 2002. Avian response to warm-season grass use in pasture and hayfield management. Biol. Conserv. 106, 1–9.

Hansson, M., Fogelfors, H., 2000. Management of a semi-natural grassland; results from a 15-year-old experiment in southern Sweden. J. Veg. Sci. 11, 31–38.

Hertel, T.W., Brockmeier, M., Swaminathan, P.V., 1997. Sectoral and economy-wide analysis of integrating Central and Eastern European countries into the EU: implications of alternative strategies. Eur. Rev. Agric. Econ. 24, 359–386.

Hole, D.G., Whittingham, M.J., Bradbury, R.B., Anderson, G.Q.A., Lee, P.L.M., Wilson, J.D., Krebs, J.R., 2002. Widespread house sparrow extinctions. Nature 418, 931–932.

Jeanneret, Ph., Schüpbach, B., Luka, H., 2003. Quantifying the impact of landscape and habitat features on biodiversity in cultivated landscapes. Agric. Ecosyst. Environ. 98, 311–320.

Jongman, R.H.G., 2002. Homogenisation and fragmentation of the European landscape: ecological consequences and solutions. Landsc. Urban Plann. 58, 211–221.

Kavcic, S., Erjavec, E., Mergos, G., Stoforos, C., 2003. EU enlargement and the common agricultural policy: the case of Slovenia. Agric. Food Sci. Finland 12, 3–19.

Kelemen, J., 1997. Irányelvek a füves területek természetvédelmi szempontú kezeléséhez. TermészetBÚVÁR Alapítvány Kiadó, Budapest, Hungary.

Kleijn, D., Sutherland, W.J., 2003. How effective are European agri-environment schemes in conserving and promoting biodiversity? J. Appl. Ecol. 40, 947–969.

Kleijn, D., Berendse, F., Smit, R., Gilissen, N., 2001. Agri-environment schemes do not effectively protect biodiversity in Dutch agricultural landscapes. Nature 413, 723–725.

Kromp, B., 1999. Carabid beetles in sustainable agriculture: a review on pest control efficacy, cultivation impacts and enhancement. Agric. Ecosyst. Environ. 74, 187–228.

Kruess, A., Tscharntke, T., 2002. Contrasting responses of plant and insect diversity to variation in grazing intensity. Biol. Conserv. 106, 293–302.

Kuiters, A.T., Slim, P.A., 2003. Tree colonisation of abandoned arable land after 27 years of horse-grazing: the role of bramble as a facilitator of oak wood regeneration. For. Ecol. Manage. 181, 239–251.

Lachenbruch, P.A., 1975. Discriminant Analysis. Hafner, New York, USA.

Lundstrom-Gillieron, C., Schlaepfer, R., 2003. Hare abundance as an indicator for urbanisation and intensification of agriculture in Western Europe. Ecol. Model. 168, 283–301.

MacDonald, D., Crabtree, J.R., Weisinger, G., Dax, Y., Stamou, N., Fleury, P., Guttierez Lazpita, J., Gibon, A., 2000. Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. J. Environ. Manage. 59, 47–69.

Maes, D., Van Dyck, H., 2001. Butterfly diversity loss in Flanders (north Belgium): Europe's worst case scenario? Biol. Conserv. 99, 263–276.

Magyar, G., Hadarics, T., Waliczky, Z., Schmidt, A., Nagy, T., Bankovics, A., 1998. Nomenclator Avium Hungariae. An annotated list of the birds of Hungary. Madártani Intézet—MME, Budapest, Hungary.

Marggraf, R., 2003. Comparative assessment of agri-environment programmes in federal states of Germany. Agric. Ecosyst. Environ. 98, 507–516.

Molnár, Z., Vajda, Z., 2000. A Duna-Tisza köze élőhely-térképezése (D-TMAP 1996–2000). Unpublished Report. Institute of Ecology and Botany of the Hungarian Academy of Sciences, Vácrátót.

Molnár, Z., Borhidi, A., 2003. Hungarian alkali vegetation: origins, landscape history, syntaxonomy, conservation. Phytocoenologia 33, 377–408.

Muller, S., 2002. Appropriate agricultural management practices required to ensure conservation and biodiversity of environmentally sensitive grassland sites designated under Natura 2000. Agric. Ecosyst. Environ. 89, 261–266.

Murphy, M.T., 2003. Avian population trends within the evolving agricultural landscape of eastern and central United States. Auk 120, 20–34.

Ovenden, G.N., Swash, A.R.H., Smallshire, D., 1998. Agri-environment schemes and their contribution to the conservation of biodiversity in England. J. Appl. Ecol. 35, 955–960.

Pärt, T., Söderström, B., 1999. Conservation value of semi-natural pastures in Sweden: contrasting botanical and avian measures. Conserv. Biol. 13, 755–765.

Peach, W.J., Lovett, L.J., Wotton, S.R., Jeffs, C., 2001. Countryside stewardship delivers cirl buntings (*Emberiza cirlus*) in Devon, UK. Biol. Conserv. 101, 361–373.

Pena, N., de la, M., Butet, A., Delettre, Y., Paillat, G., Morant, P., Du, L.E., Burel, F., 2003. Response of the small mammal community to changes in western French agricultural landscapes. Landsc. Ecol. 18, 265–278.

Petersen, B.S., Jacobsen, E.M., 1997. Population Trends in Danish Farmland Birds. Danish Environmental Protection Agency, Copenhagen, Denmark.

Primdahl, J., Peco, B., Schramek, J., Andersen, E., Onate, J.J., 2003. Environmental effects of agri-environmental schemes in Western Europe. J. Environ. Manage. 67, 129–138.

Pywell, R.F., Bullock, J.M., Hopkins, A., Walker, K.J., Sparks, T.H., Burke, M.J.W., Peel, S., 2002. Restoration of species-rich grassland on arable land: assessing the limiting processes using a multi-site experiment. J. Appl. Ecol. 39, 294–309.

Robinson, R.A., Sutherland, W.J., 2002. Changes in arable farming and biodiversity in Great Britain. J. Appl. Ecol. 39, 157–176.

Roudna, M., Dotlacil, L., 2002. Agricultural biological diversity in CEE countries. High-level Pan-European Conference on Agriculture and Biodiversity: towards integrating biological and landscape diversity for sustainable agriculture in Europe. Paris, France. http://www.nature.coe.int/CONF_AGRI_2002/.

Schifferli, L., Fuller, R.J., Müller, M., 1999. Distribution and habitat use of bird species breeding on Swiss farmland in relation to agricultural intensification. Vogelwelt 120 (Suppl.), 151–161.

Siriwardena, G.M., Baillie, S.R., Buckland, S.T., Fewster, R.M., Marchant, J.H., Wilson, J.D., 1998. Trends in the abundance of farmland birds: a quantitative comparison of smoothed common bird census indices. J. Appl. Ecol. 35, 24–43.

SPSS, 1999. SPSS Base 10.0. SPSS Inc., Chicago, USA.

Stoate, C., Boatman, N.D., Borralho, R.J., Carvalho, C.R., de Snoo, G.R., Eden, P., 2001. Ecological impacts of arable intensification in Europe. J. Environ. Manage. 63, 337–365.

Stoate, C., Araújo, M., Borralho, R., 2003. Conservation of European farmland birds: abundance and species diversity. Ornis Hung 12–13, 33–41.

Suárez-Seoane, S., Osborne, P.E., Baudry, J., 2002. Responses of birds of different biogeographic origins and habitat requirements to agricultural land abandonment in northern Spain. Biol. Conserv. 105, 333–344.

Suominen, O., Niemela, J., Martikainen, P., Niemela, P., Kojola, I., 2003. Impact of reindeer grazing on ground-dwelling Carabidae and Curculionidae assemblages in Lapland. Ecography 26, 503–513.

Sutherland, W.J., 2002. Restoring a sustainable countryside. Trends Ecol. Evol. 17, 148–150.

Szép, T., Nagy, K., 2002. Mindennapi Madaraink Monitoringja (MMM) 1999–2000. MME BirdLife Hungary, Budapest, Hungary.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W.H., Simberloff, D., Swackhamer, D., 2001. Forecasting agriculturally driven global environmental change. Science 292, 281–284.

Tscharntke, T., Steffan-Dewenter, I., Kruess, A., Thies, C., 2002. Contribution of small habitat fragments to conservation of insect communities of grassland-cropland landscapes. Ecol. Appl. 12, 354–363.

Teunissen, W.A., Hagemeijer, W.J.M., 1999. Meadow bird protection by volunteers in the Netherlands: can it stop the decline in numbers? Vogelwelt 120 (Suppl.), 193–200.

Tucker, G.M., Heath, M., 1994. Birds in Europe: their Conservation Status. BirdLife International, Cambridge, UK.

Varga, Z., 1995. Geographical patterns of biological diversity in the Palaearctic region and the Carpathian Basin. Acta Zool. Hung. 41, 71–92.

Varga, Z., 1997. Dry grasslands of the Pannonian lowland: relation of physiognomic structure and floristic composition to certain insect groups. Phytocoenologia 27, 509–571.

Verhulst, J., Báldi, A., Kleijn, D., 2004. The relation between land-use intensity and species-richness and abundance of birds in Hungary. Agric. Ecosyst. Environ. 104, 465–473.

Vickery, J.A., Tallowin, J.R., Feber, R.E., Asteraki, E.J., Atkinson, P.W., Fuller, R.J., Brown, V.K., 2001. The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. J. Appl. Ecol. 38, 647–664.

Wilson, J.D., Morris, A.J., Arroyo, B.E., Clark, S.C., Bradbury, R.B., 1999. A review of the abundance and diversity of invertebrate and plant foods of granivorous birds in northern Europe in relation to agricultural change. Agric. Ecosyst. Environ. 75, 13–30.

Zechmeister, H.G., Schmitzberger, I., Steurer, B., Peterseil, J., Wrbka, T., 2003. The influence of land-use practices and economics on plant species richness in meadows. Biol. Conserv. 114, 165–177.